

Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

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1. **Introduction:** CM-SAF, CLARA, radiative flux products
2. **Developing** the CDR: details of algorithm
3. **Results and validation** with CERES datasets
4. **Conclusions** and outlook

What is CM SAF?

- Climate products from (weather) satellites
- Part of EUM ground segment
- Products target the energy and water cycles*
- 3 types of products:
 - EDR = Environmental Data Record
 - ICDR = Interim Climate Data Record
 - TCDR = Thematic Climate Data Record
- Global/regional products
- Polar and geo satellites
- User's oriented programme: help desk, web user ordering system, users training events, ...
- Operational: annual quality ass., Review, operation reviews, ...
- Guidance from a steering group, visiting scientist programme, ...



The screenshot shows the CM SAF website homepage. At the top, it says 'The Satellite Application Facility on Climate Monitoring'. There are navigation tabs for Overview, Products, Data Access, Documentation, and Training. A search bar is visible. The main content area includes a 'News' section with links to newsletters and service messages, a 'Service' section with links for contact, FAQ, glossary, and links, and a 'Consortium' section listing partner organizations like the Swedish Meteorological and Hydrological Institute and the Swiss Confederation. A large satellite image of a cloud-covered landscape is featured, with a caption 'The Satellite Application Facility on Climate Monitoring (CM SAF)'. Below that, a 'Highlights' section features a map of Europe titled 'Climate Atlas based on CM SAF data sets' with a brief description of the atlas and its availability.

(*) The energy and water cycles:

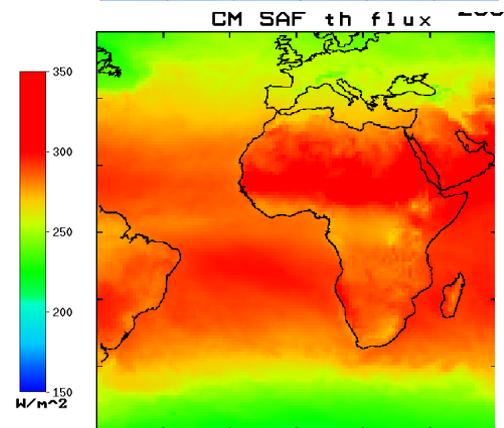
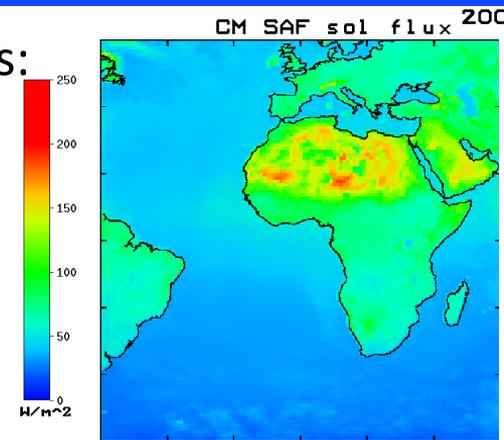
- TOA and surface radiation
- Cloud properties
- TCWV + profiles
- HOAPS retrieval (SSM/I)
- Precipitation
- Aerosol
- Surface albedo, LST, latent/sensible heat fluxes

Meteosat instruments used in CMSAF for TOA radiation products:

- Broadband radiometer: GERB (*channels TOT+SW, 44x44km*)
- Imager: MVIRI (*MFG, 1977-2006*), SEVIRI (*MSG, 2004-...*)

Current TOA radiation products in the CMSAF:

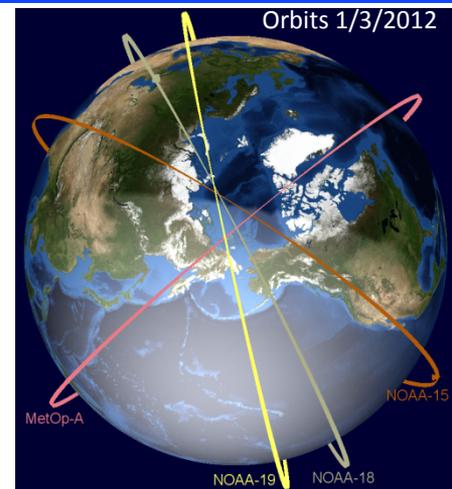
- MVIRI/SEVIRI ed01 data record (Urbain et al., 2017):
 - Long data record 1982-2015
 - GERB used “offline”
 - Released January 2017
 - Resolution $0.05^\circ \times 0.05^\circ$
- GERB/SEVIRI ed02 data record (Clerboux et al., 2017):
 - Feb. 2004 - April 2015
 - Drift corrected
 - All sky and clear sky fluxes
 - Just released, 21 Sept. 2017
 - Resolution $0.1^\circ \times 0.1^\circ$



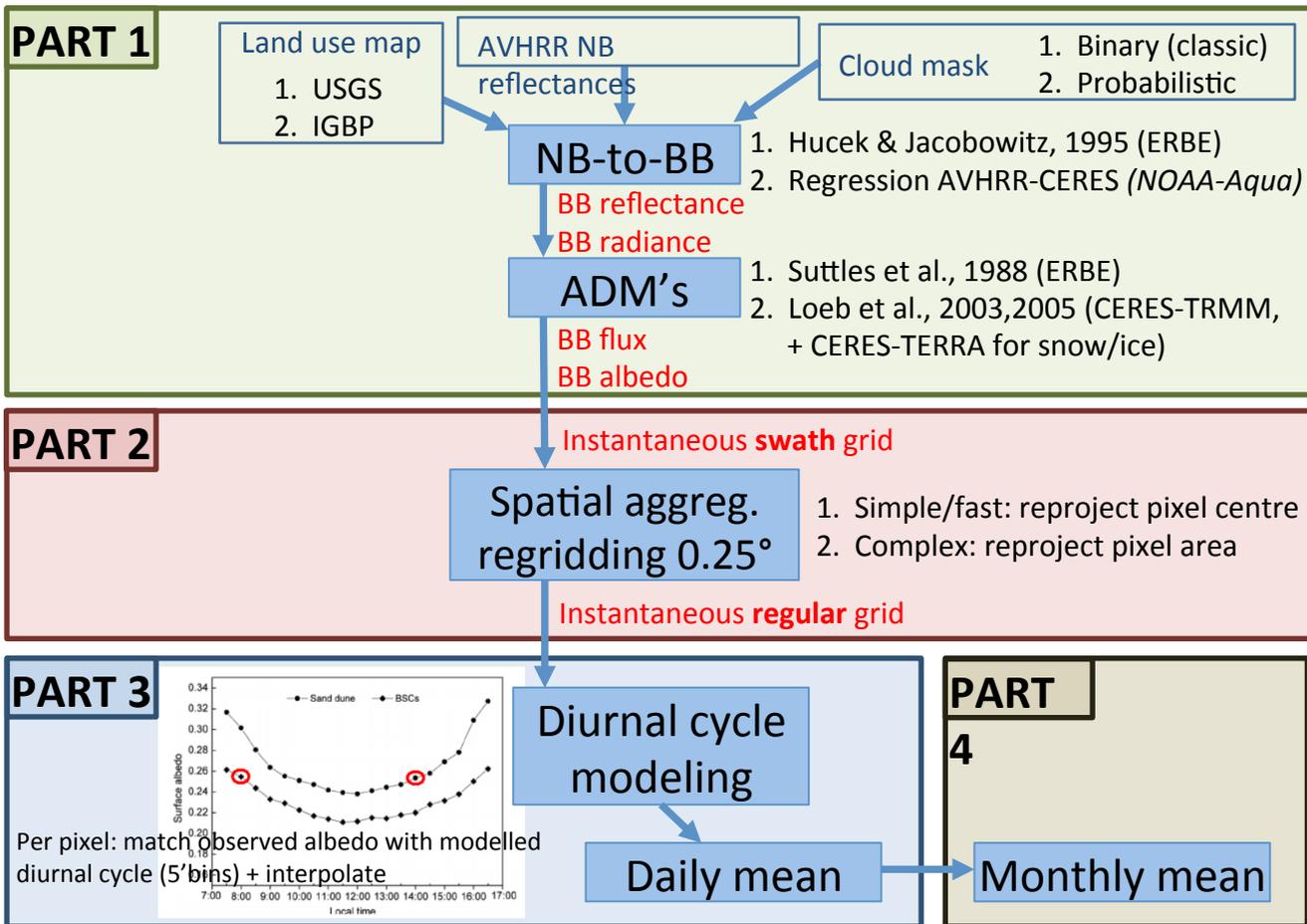
Example GERB/SEVIRI product: monthly mean clear sky solar (top) and thermal (bottom) for April 2004

What is CLARA? “CM SAF cLOUD, Albedo and RAdiation dataset from AVHRR data” (=Similar to Patmos-X)

- Only polar orbiting satellites NOAA and MetOp
- FCDR from NOAA (Heidinger et al.,2010)
- Currently released versions:
 - CLARA-A1 (Karlsson et al.,2013): 1982-2009 i.e. 28yr
 - CLARA-A2 (Karlsson et al.,2017): 1982-2015 i.e. 34yr; +improved FCDR
- Some of the modifications in upcoming version CLARA-A3:
 - Inclusion of AVHRR-1 sensor (TIROS-N, NOAA-6, -8, -10): extension of time range to 1978-2019 i.e. 42yr
 - Updated FCDR, from FiduCEO project (<http://www.fiduCEO.eu>) 
 - Updated cloud treatment algorithms (NWCSAF/PPS v.2018; Karlsson et al.) 
 - **Addition of new product “TOA radiative fluxes” -> this presentation**



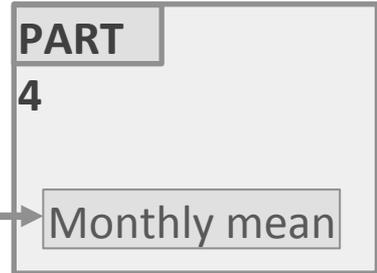
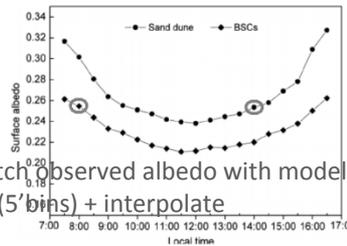
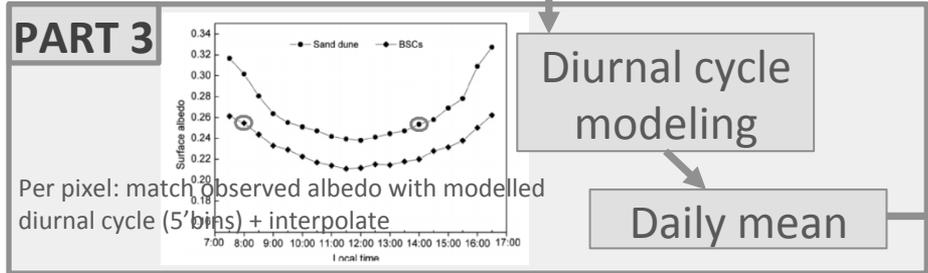
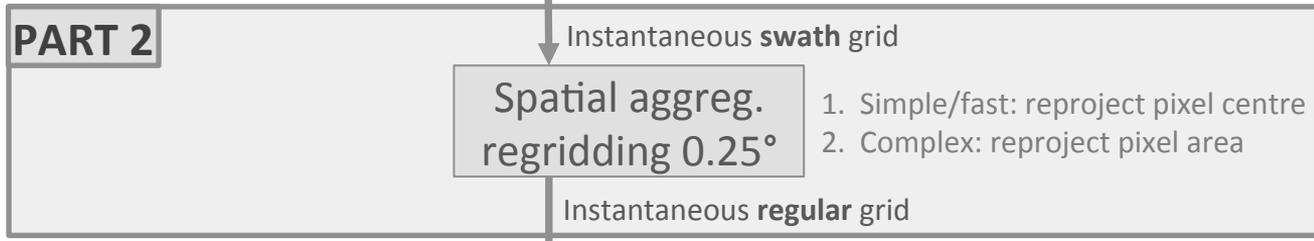
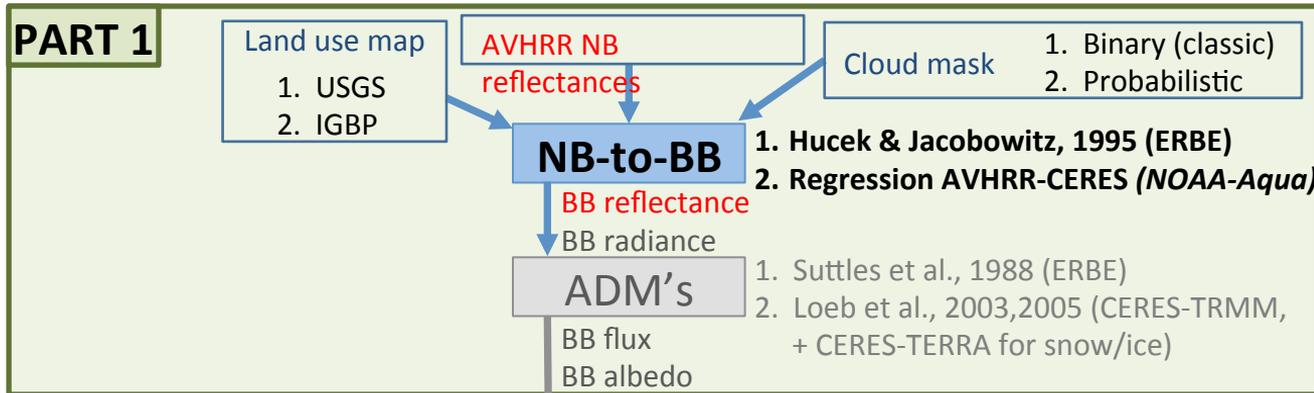
2. Development of algorithm



2. Development of algorithm

Narrowband-to-broadband conversion:

- Default: H&J,1995 (ERBE)
- Currently in development: regression AVHRR-CERES



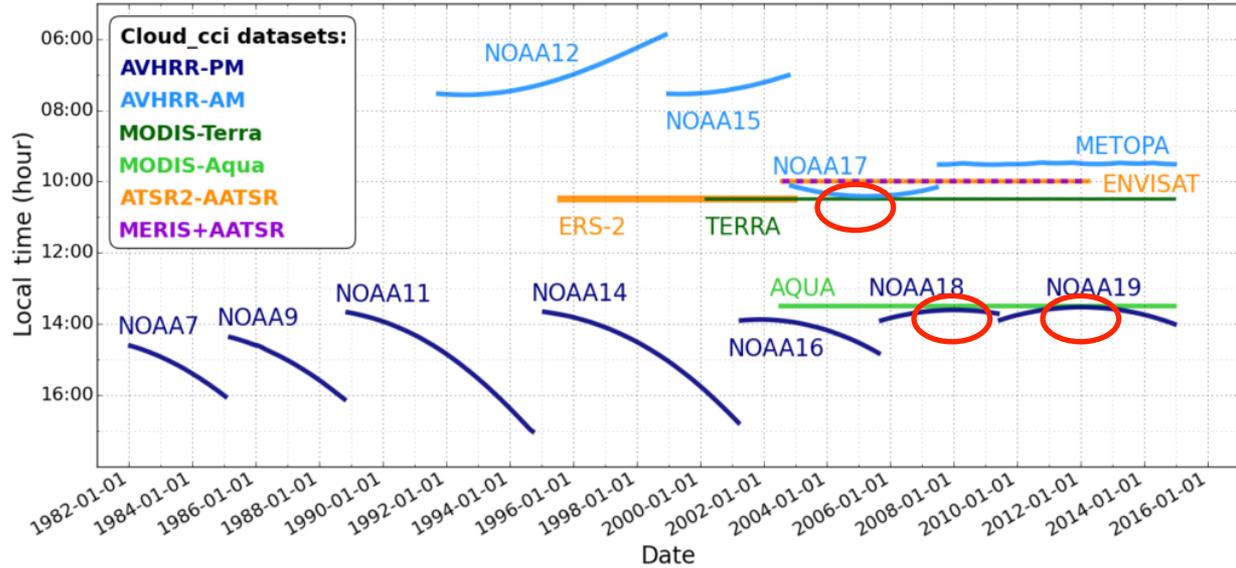
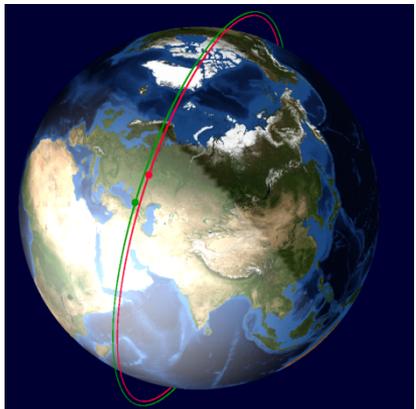
2. Development of algorithm



- CERES -> AQUA orbit: 700km, period 99'
- AVHRR -> NOAA19 orbit: 850km, period 102' (slower)

Chances of having simultaneous observations will be highest with coinciding orbital plane (=similar local solar time): hence focus on these months to gather data:

- 01/2012 (NOAA19xAQUA)
- 01/2008 (NOAA18xAQUA)
- 01/2005 (NOAA17xTERRA)

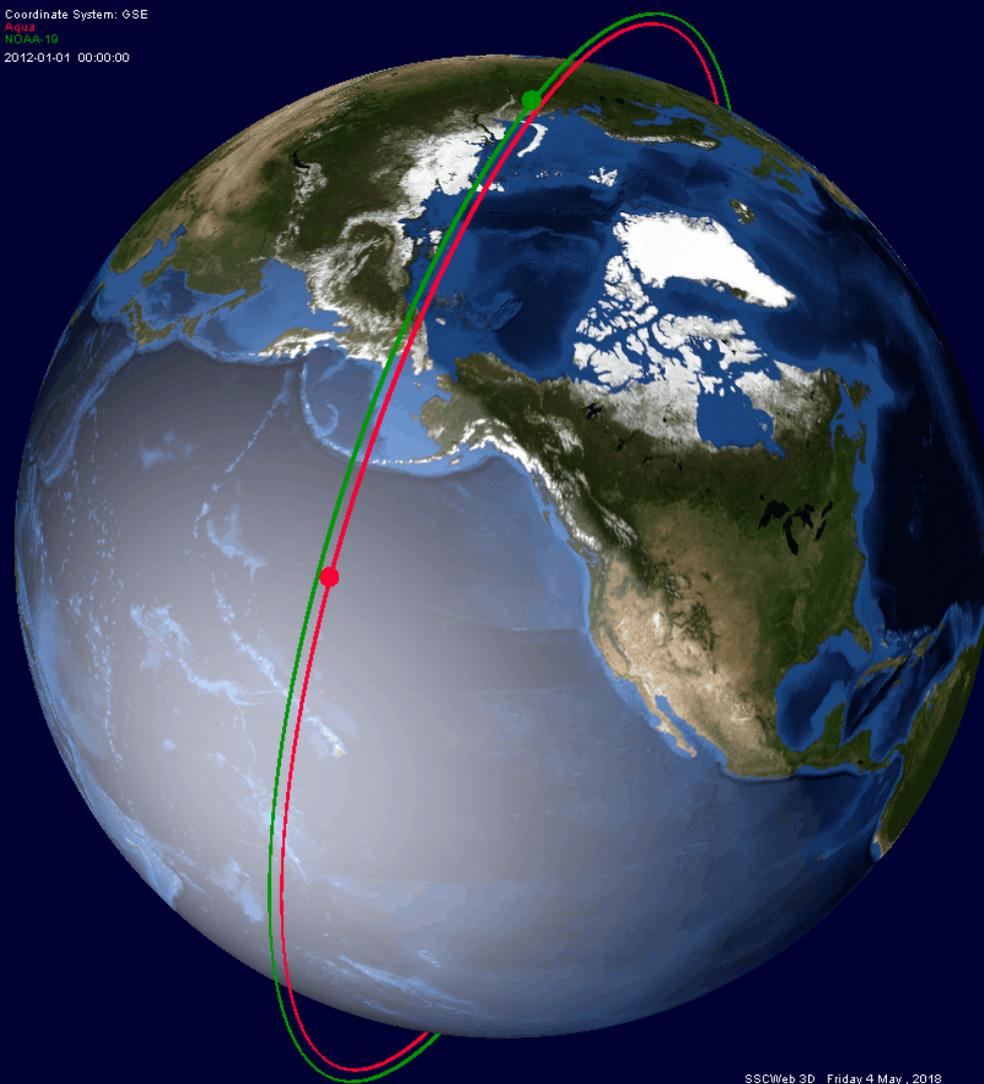


Within coinciding orbital plane:

- AVHRR -> NOAA19 orbit:
850km, period 102' (slower)
- CERES -> AQUA orbit:
700km, period 99' (faster)

At least once every 48 hours,
 the faster AQUA catches up
 with the slower NOAA19: close
 to this point, observations by
 both satellites have:

- Minimal time lag
 - Similar viewing geometry
- = coangular/collocated match



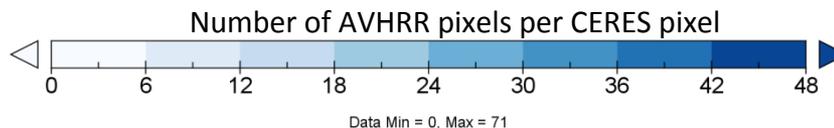
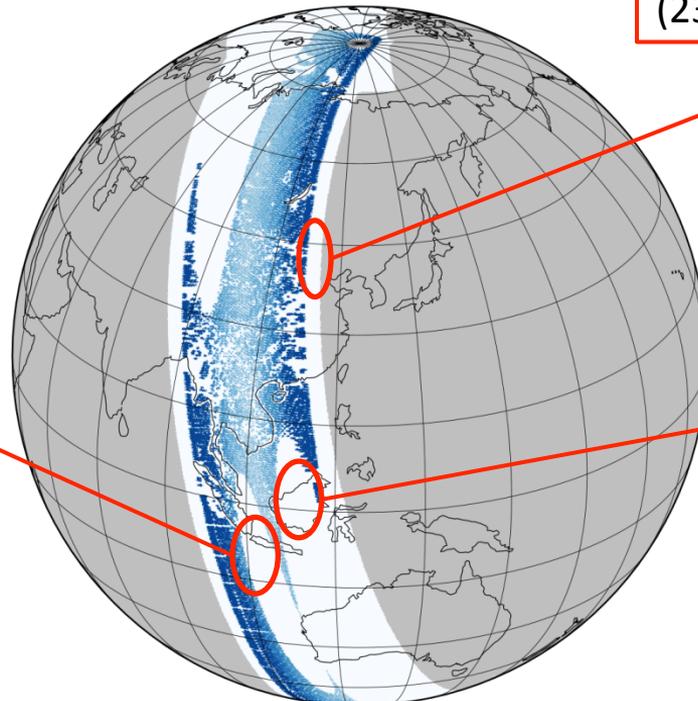
2. Development of algorithm

Example of AVHRR-CERES coangular/collocated matches:

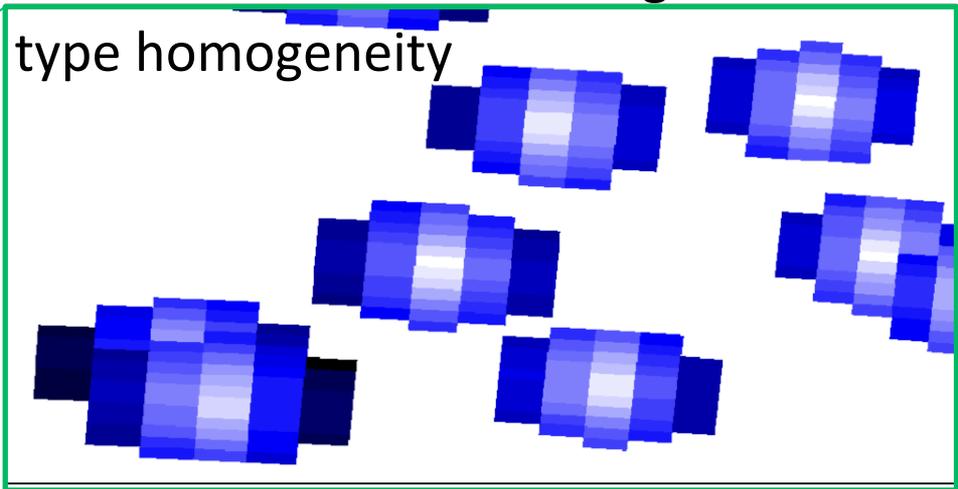
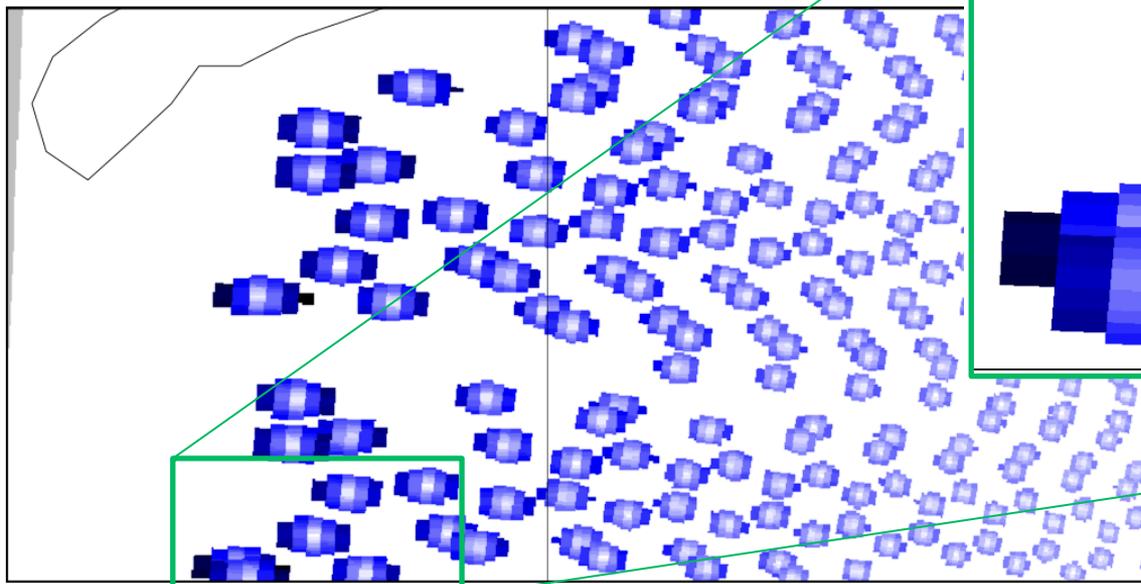
Swath width difference
(2300km vs 2900km)

Sun glint angle $< 25^\circ$:
automatic exclusion of
pixels

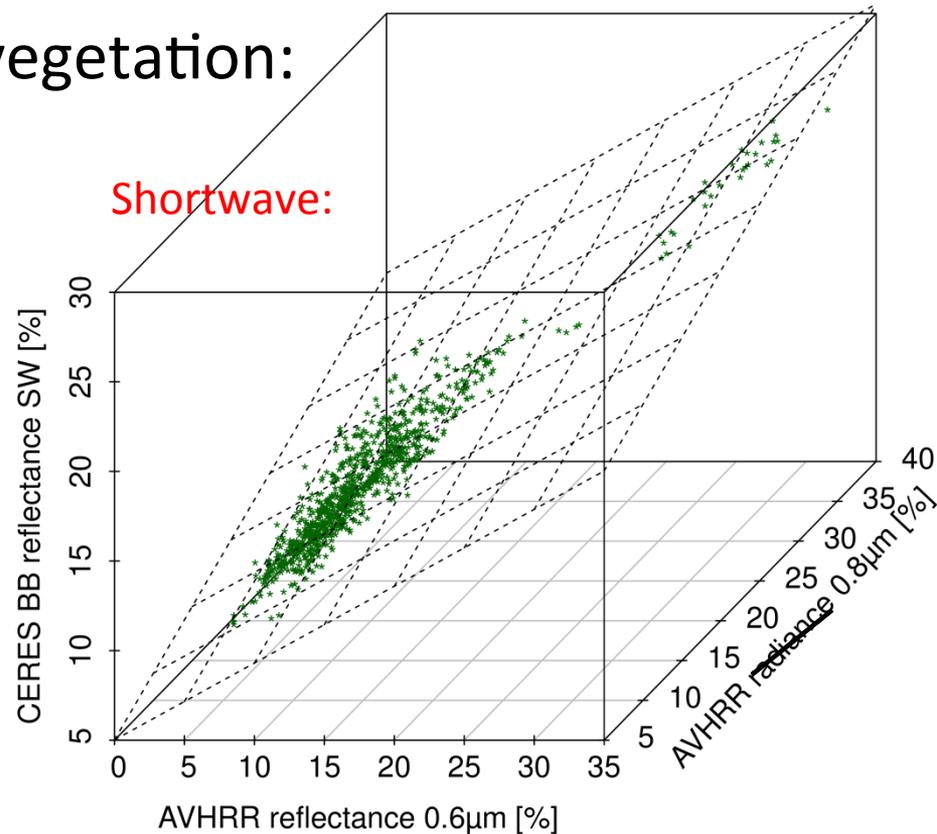
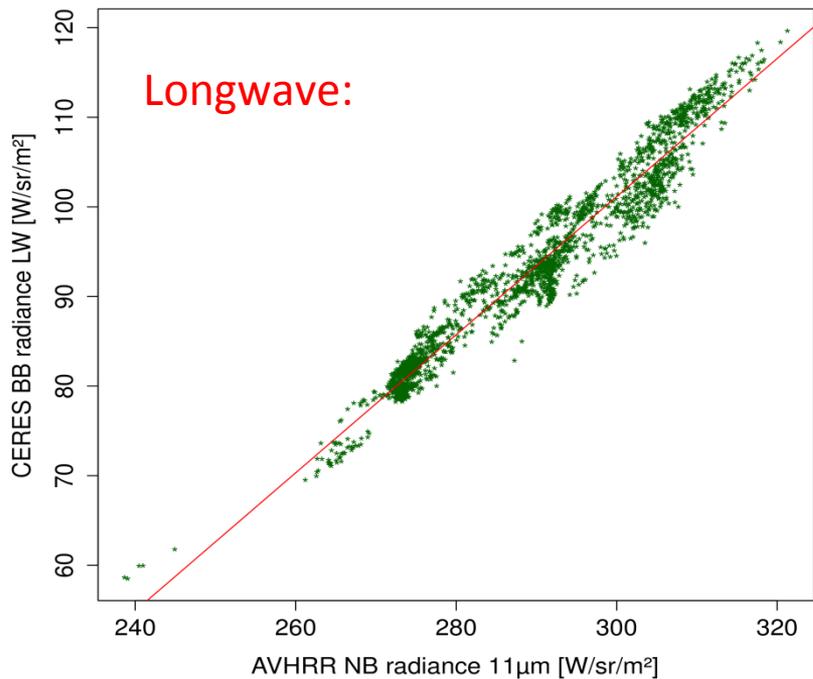
3D viewing angle
difference $> 6^\circ$:
automatic exclusion of
pixels

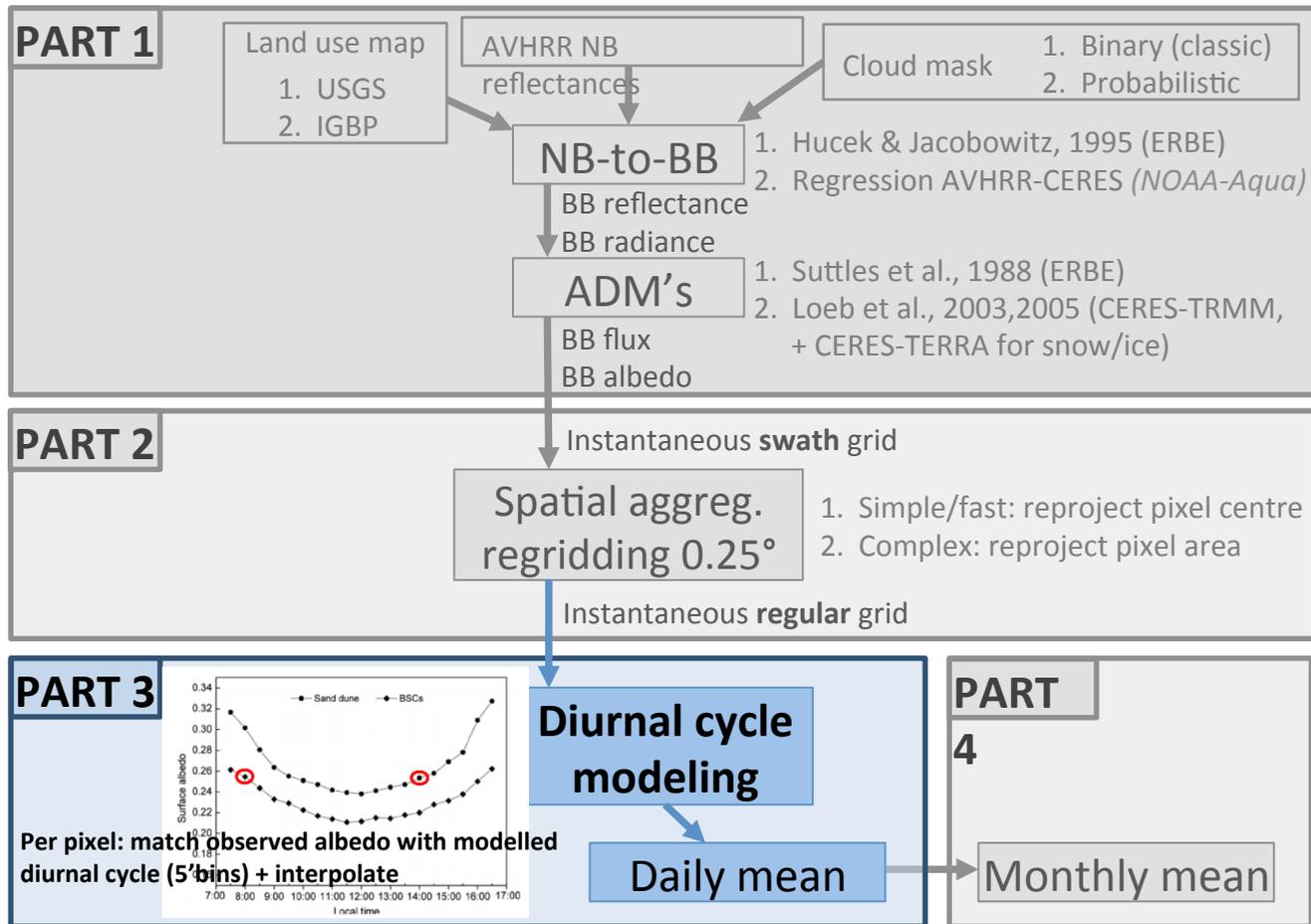


- AVHRR pixels with pixel centre inside CERES SSF pixel are considered:
 - Elliptical deformation of CERES pixel along scanline is explicitly modelled, incl. impact of viewing angle and earth curvature.
- Temporal (<300s) and angular (<3°) constraints in collocation algorithm.
- Only CERES pixels with 100% surface type homogeneity



- NB-to-BB regression parameters for each CERES surface type
- Example: regressions for dark vegetation:

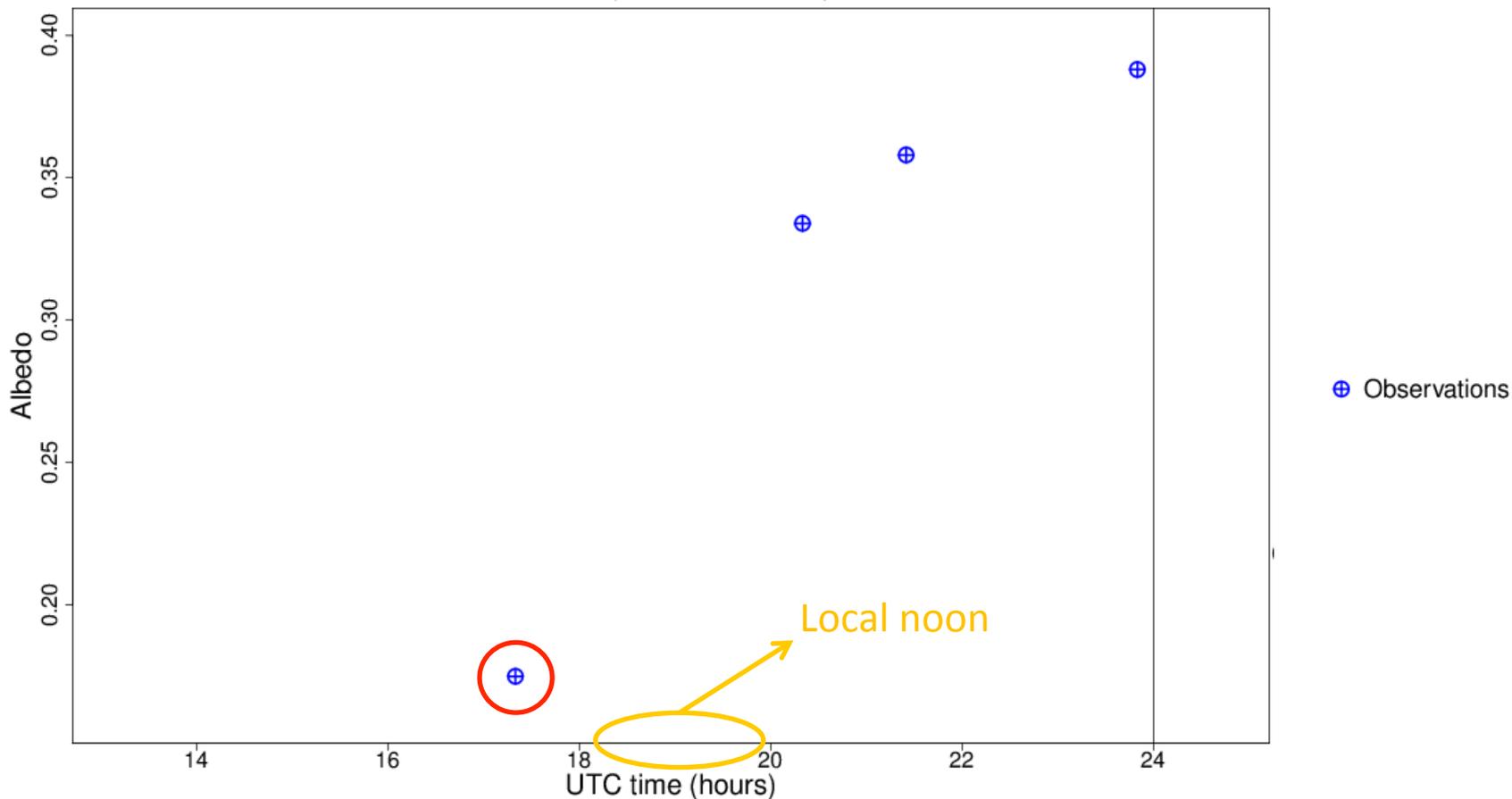




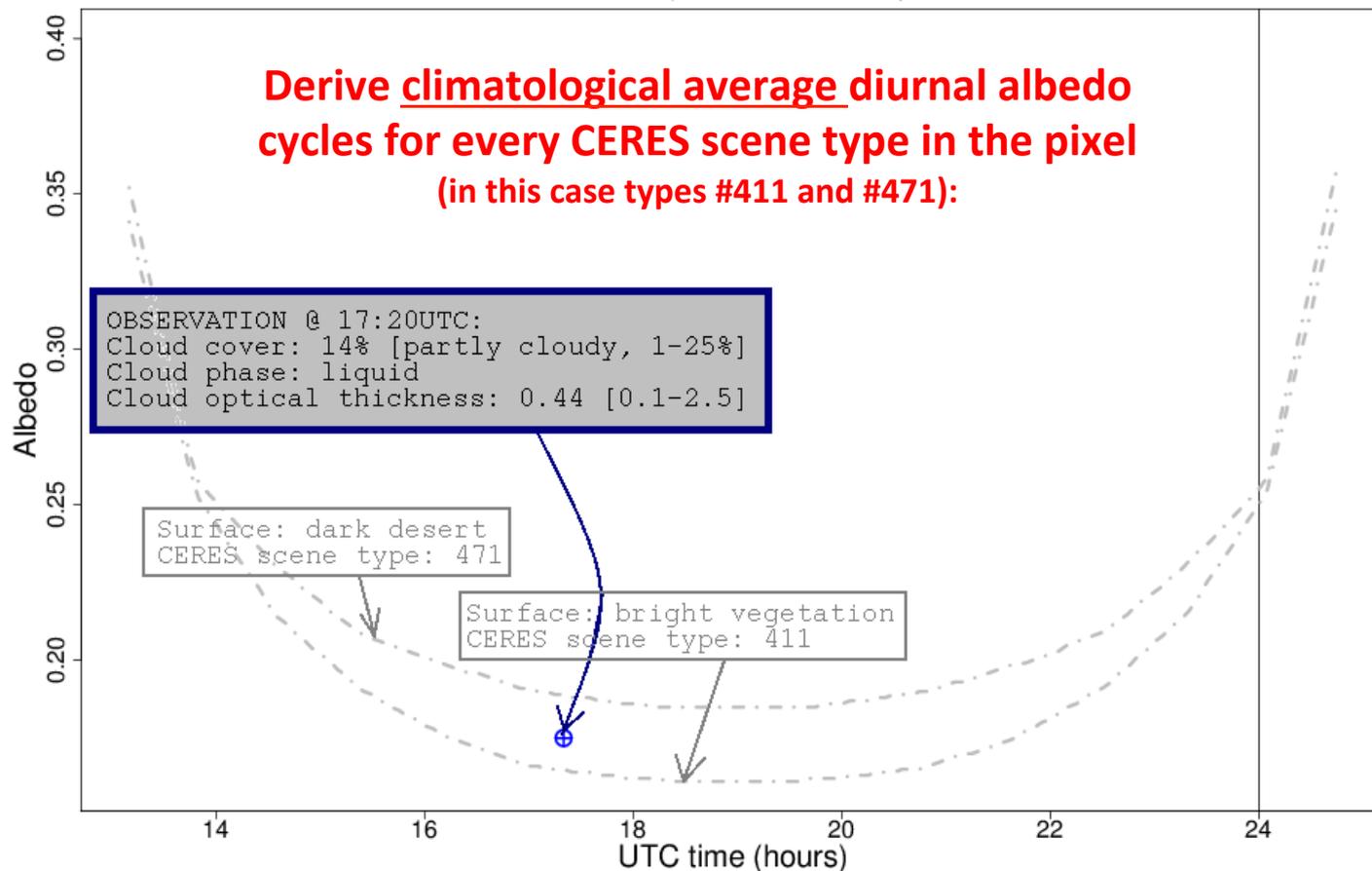
- Diurnal cycle modeling:
- Based on Young et al., 1998
 - cfr. CO-method in TISA (Doelling et al., 2013)

2. Development of algorithm

Date: 20120902; Location: 30°N, -105°E



Date: 20120902; Location: 30°N, -105°E

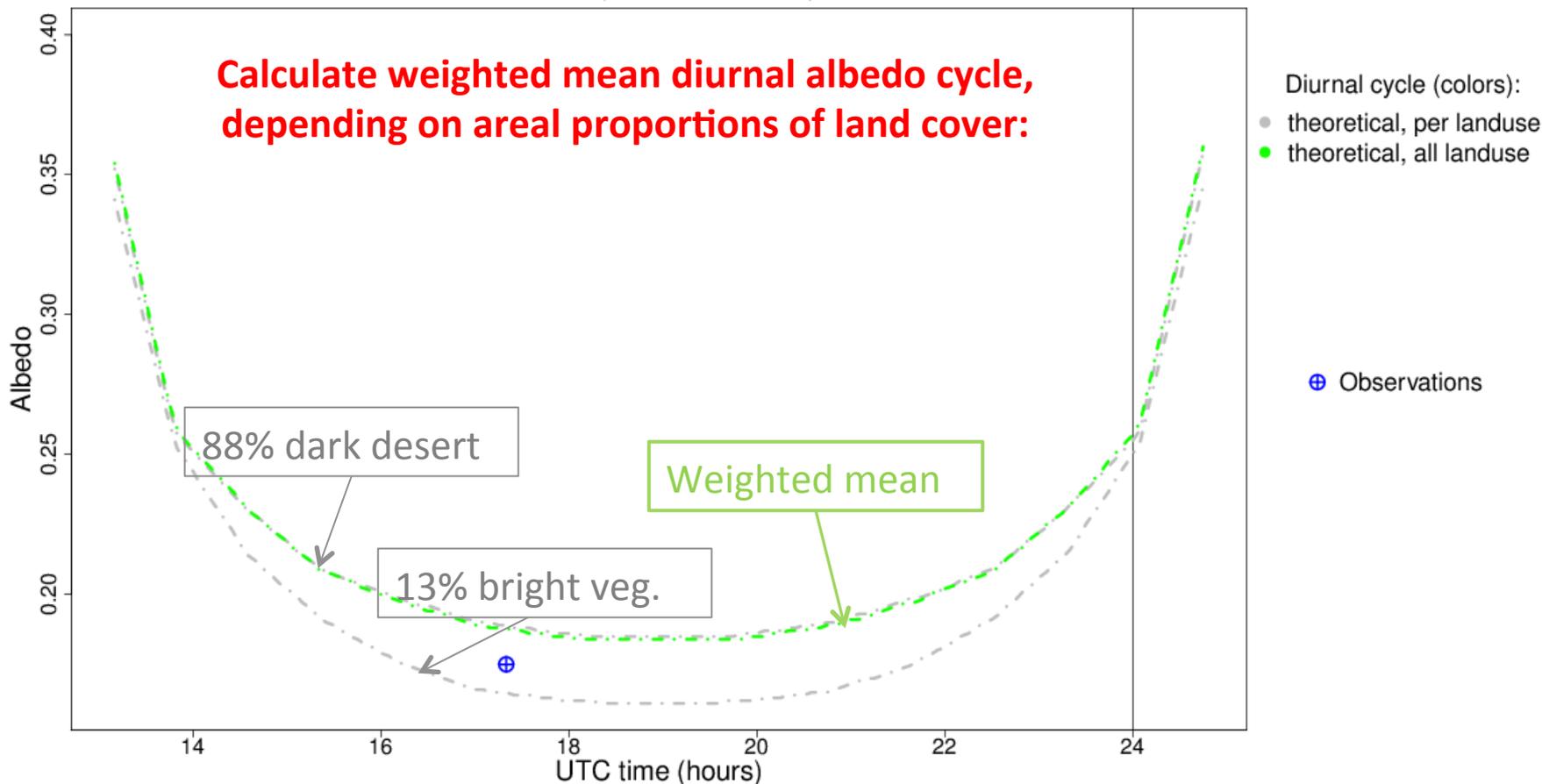


Diurnal cycle (colors):
 ● theoretical, per landuse

⊕ Observations

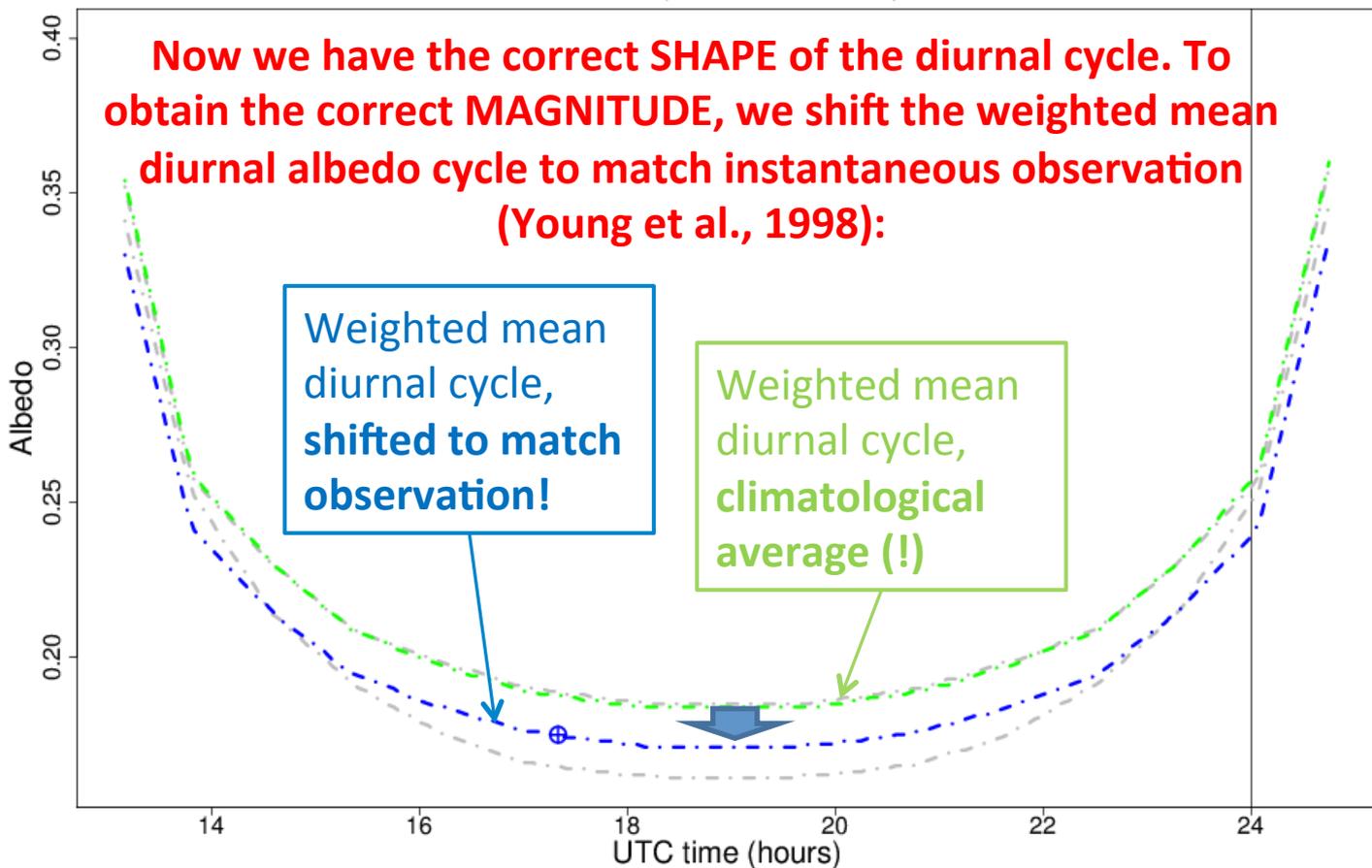
2. Development of algorithm

Date: 20120902; Location: 30°N, -105°E



2. Development of algorithm

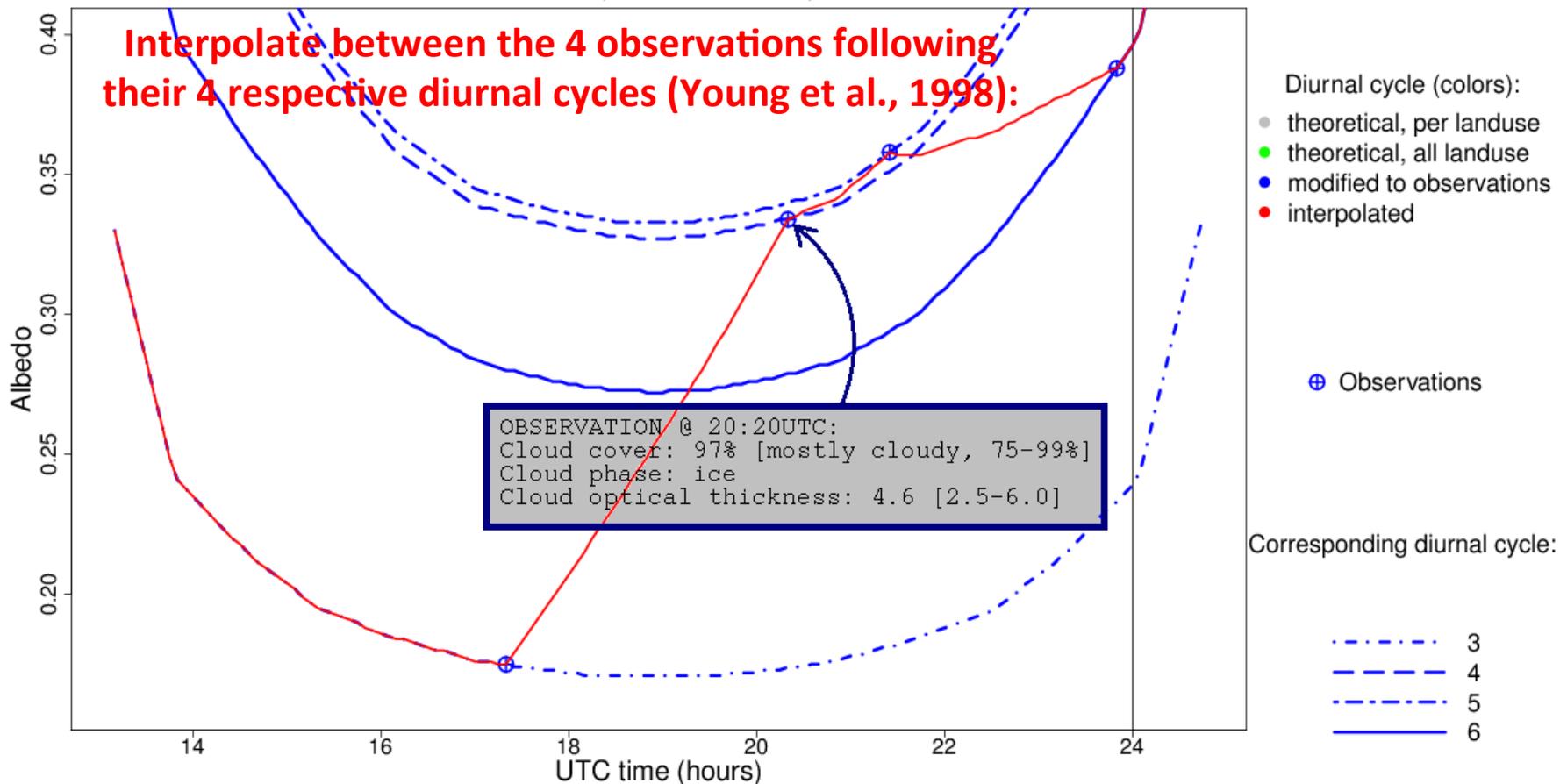
Date: 20120902; Location: 30°N, -105°E



- Diurnal cycle (colors):
- theoretical, per landuse
 - theoretical, all landuse
 - modified to observations
- ⊕ Observations

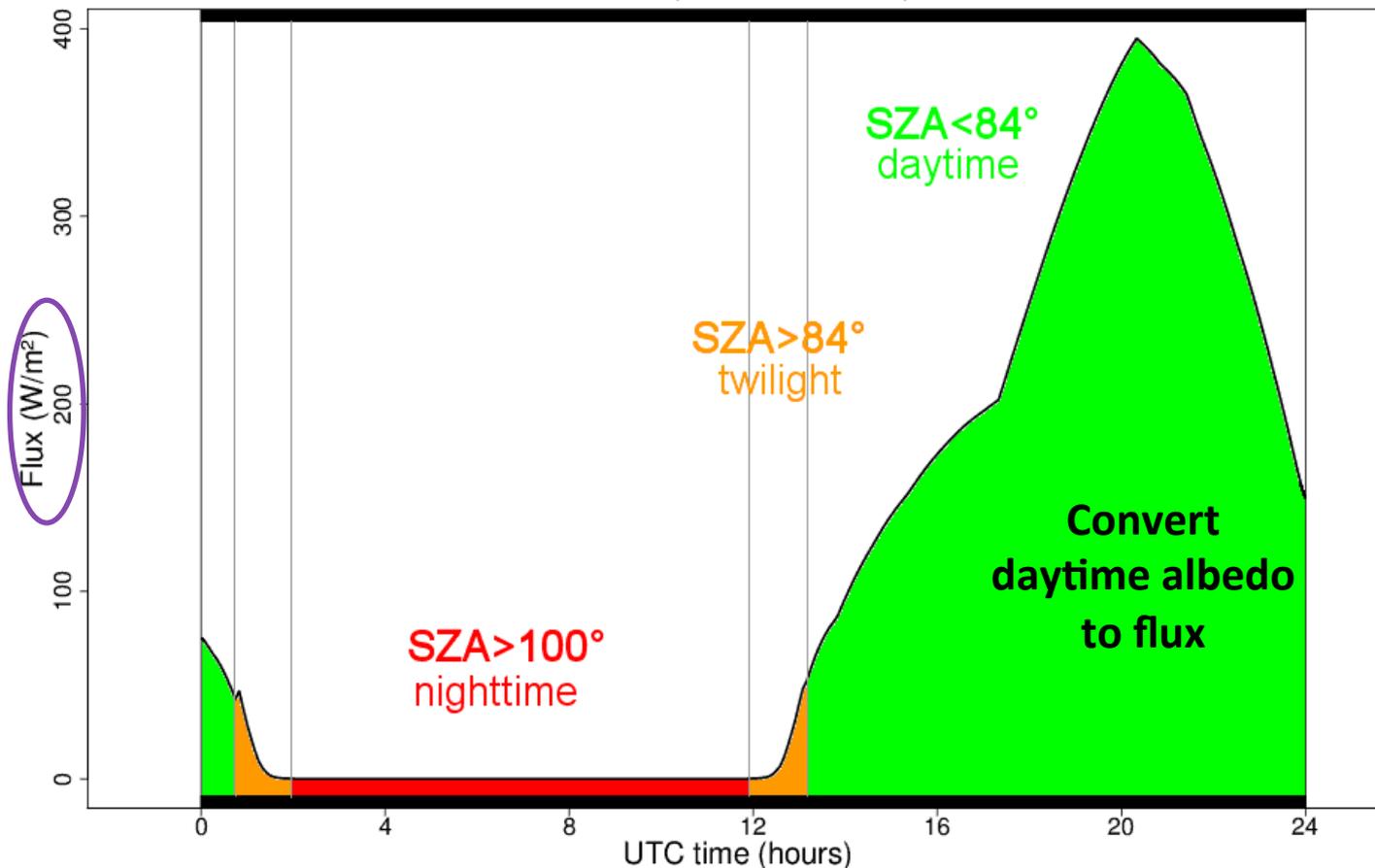
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Date: 20120902; Location: 30°N, -105°E

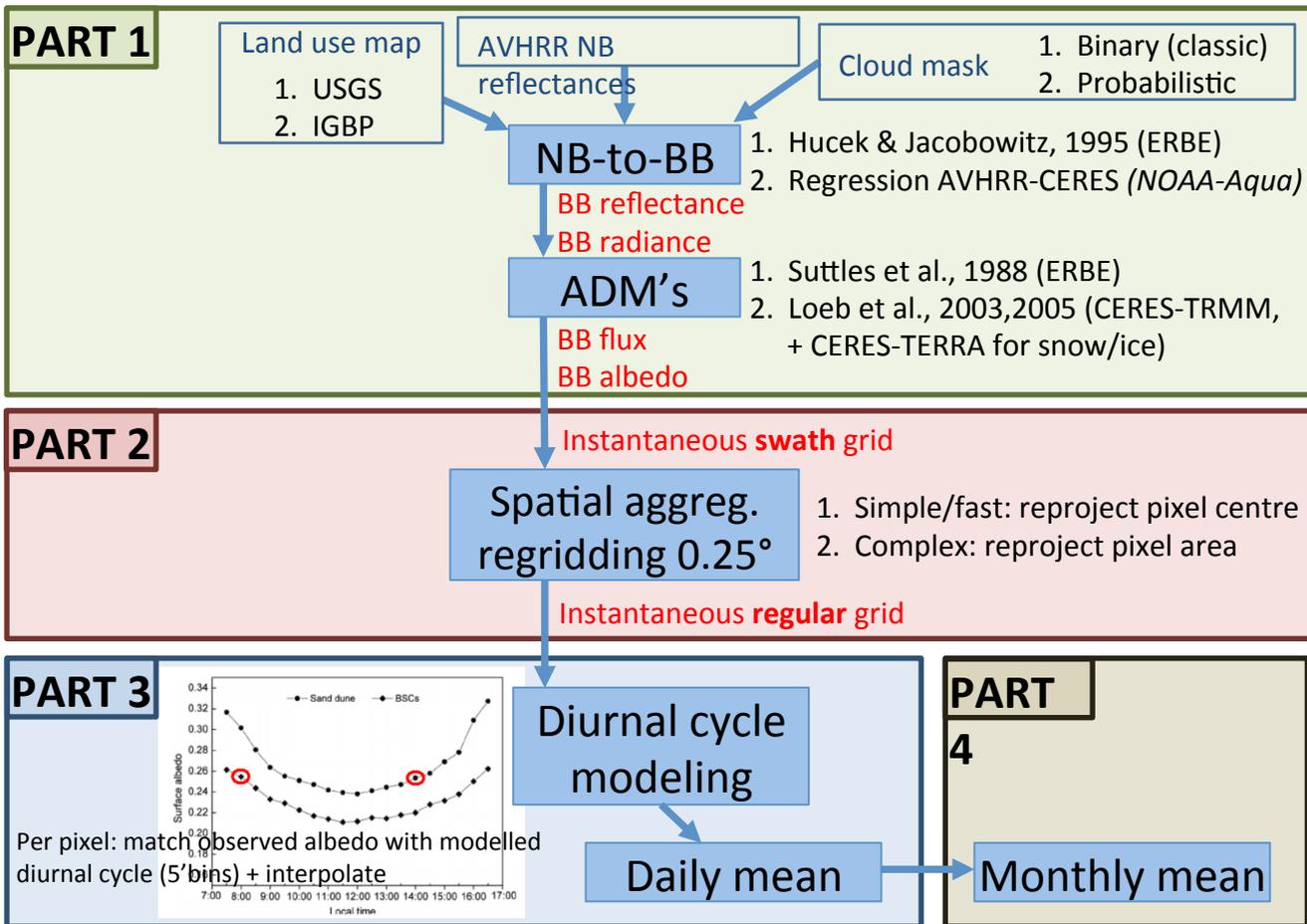


2. Development of algorithm

Date: 20120902; Location: 30°N, -105°E



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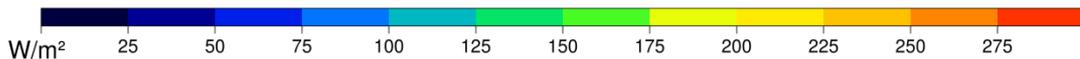
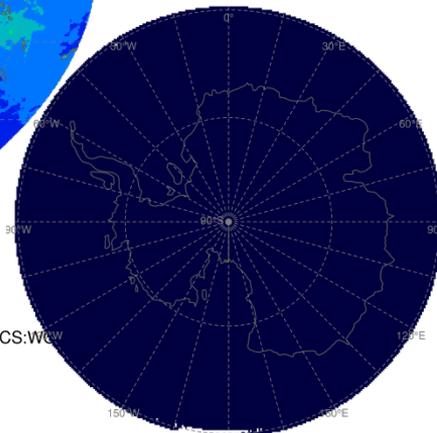
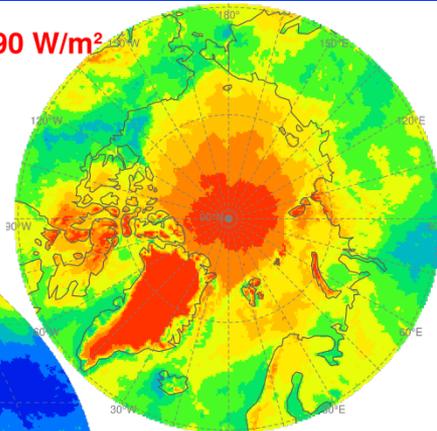
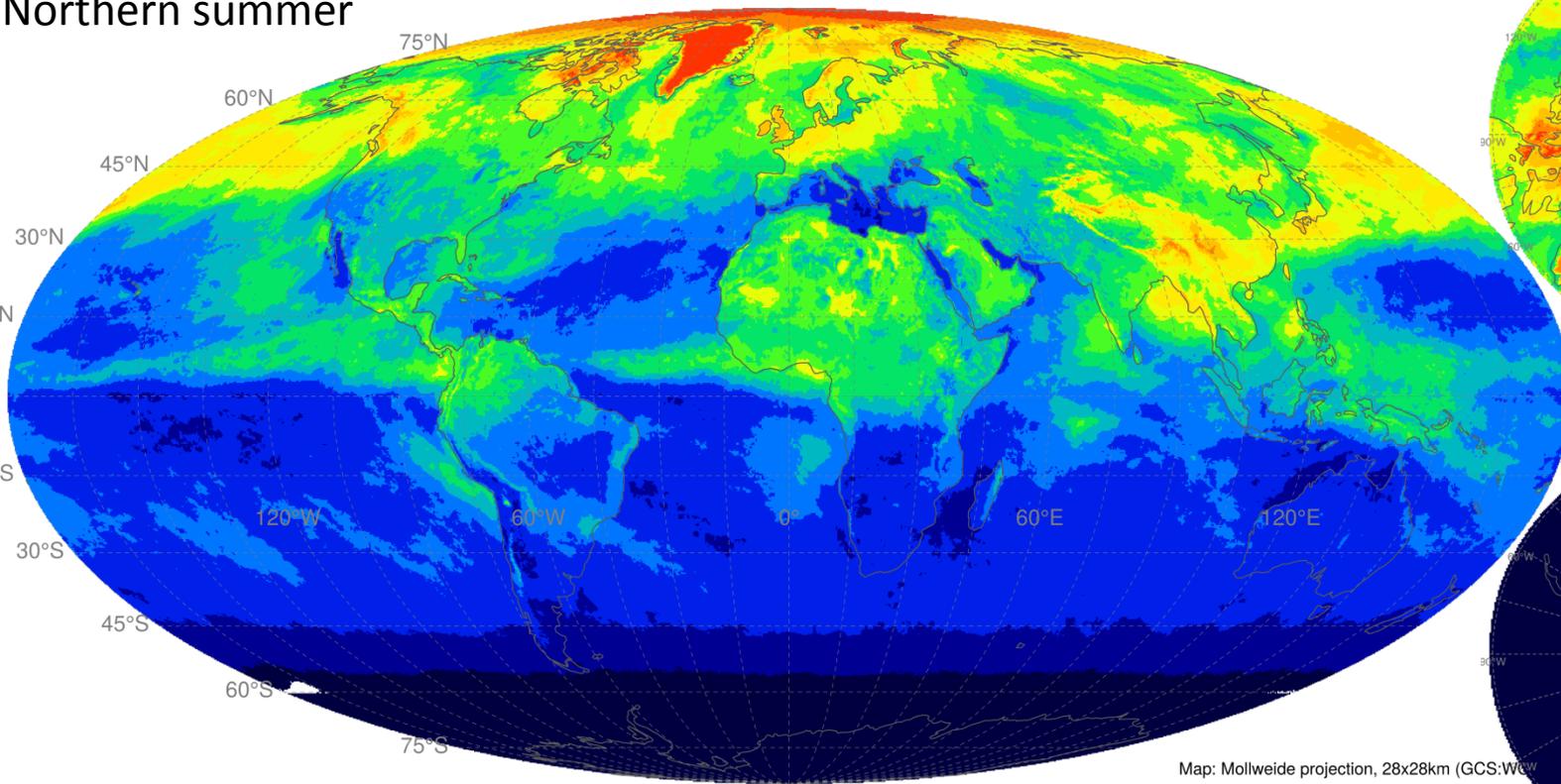


3. Results/validation

CLARA-A3 TOA SW radiation (201206)

Northern summer

Mean=97.90 W/m²



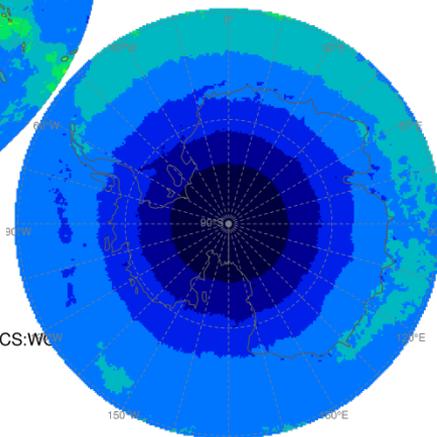
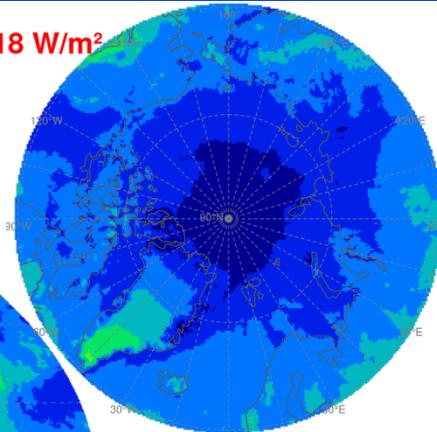
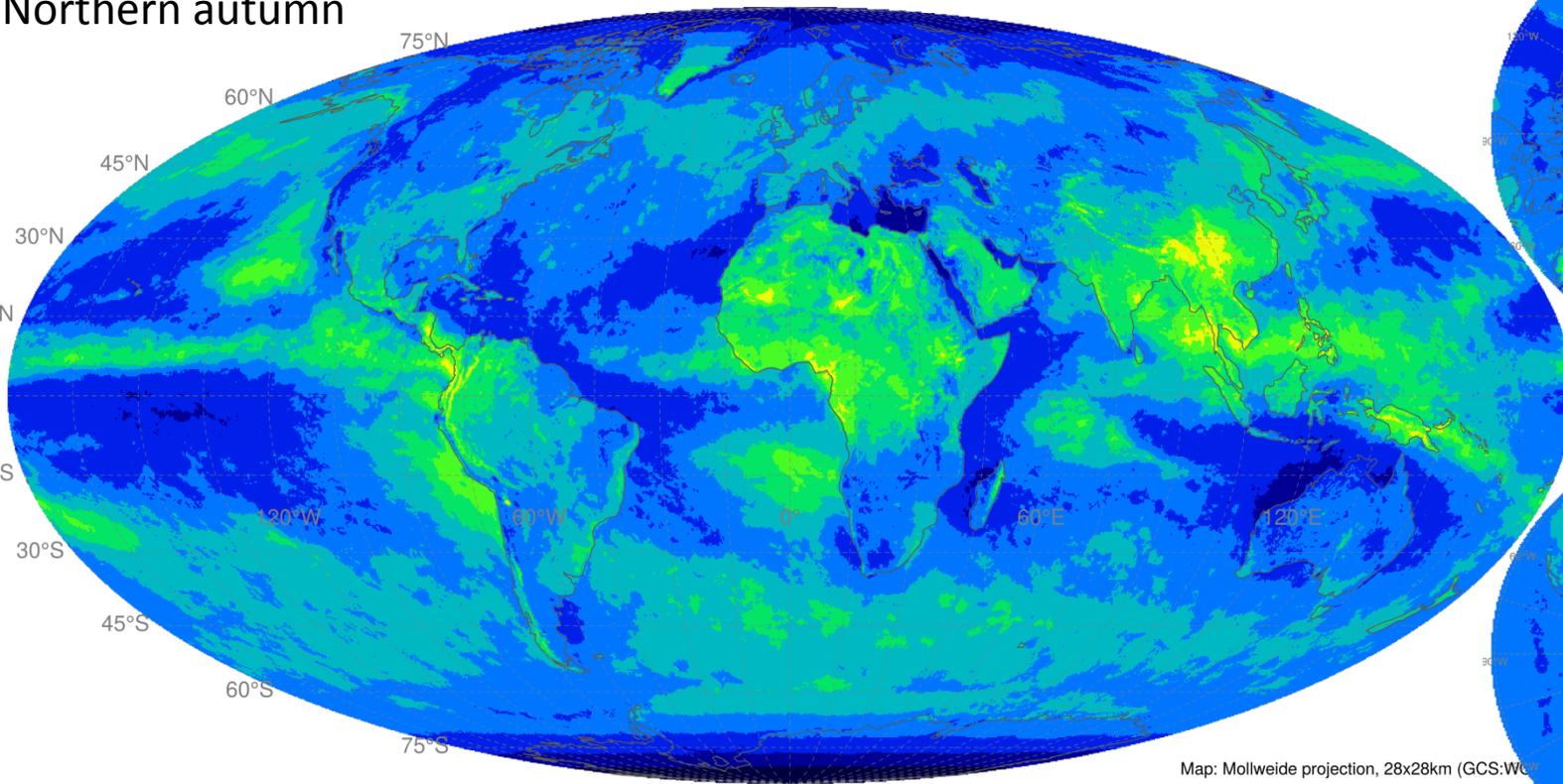
Map: Mollweide projection, 28x28km (GCS:WGS84)

3. Results/validation

CLARA-A3 TOA SW radiation (201209)

Northern autumn

Mean=97.18 W/m²



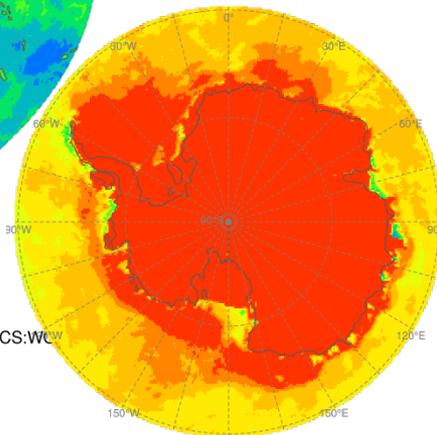
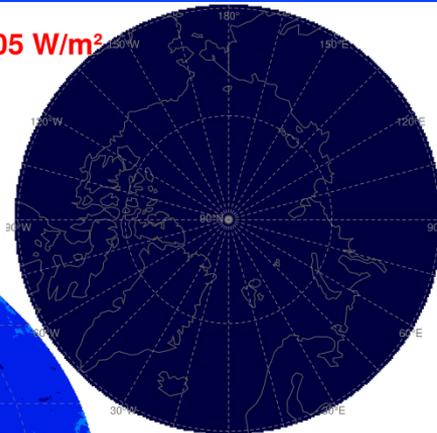
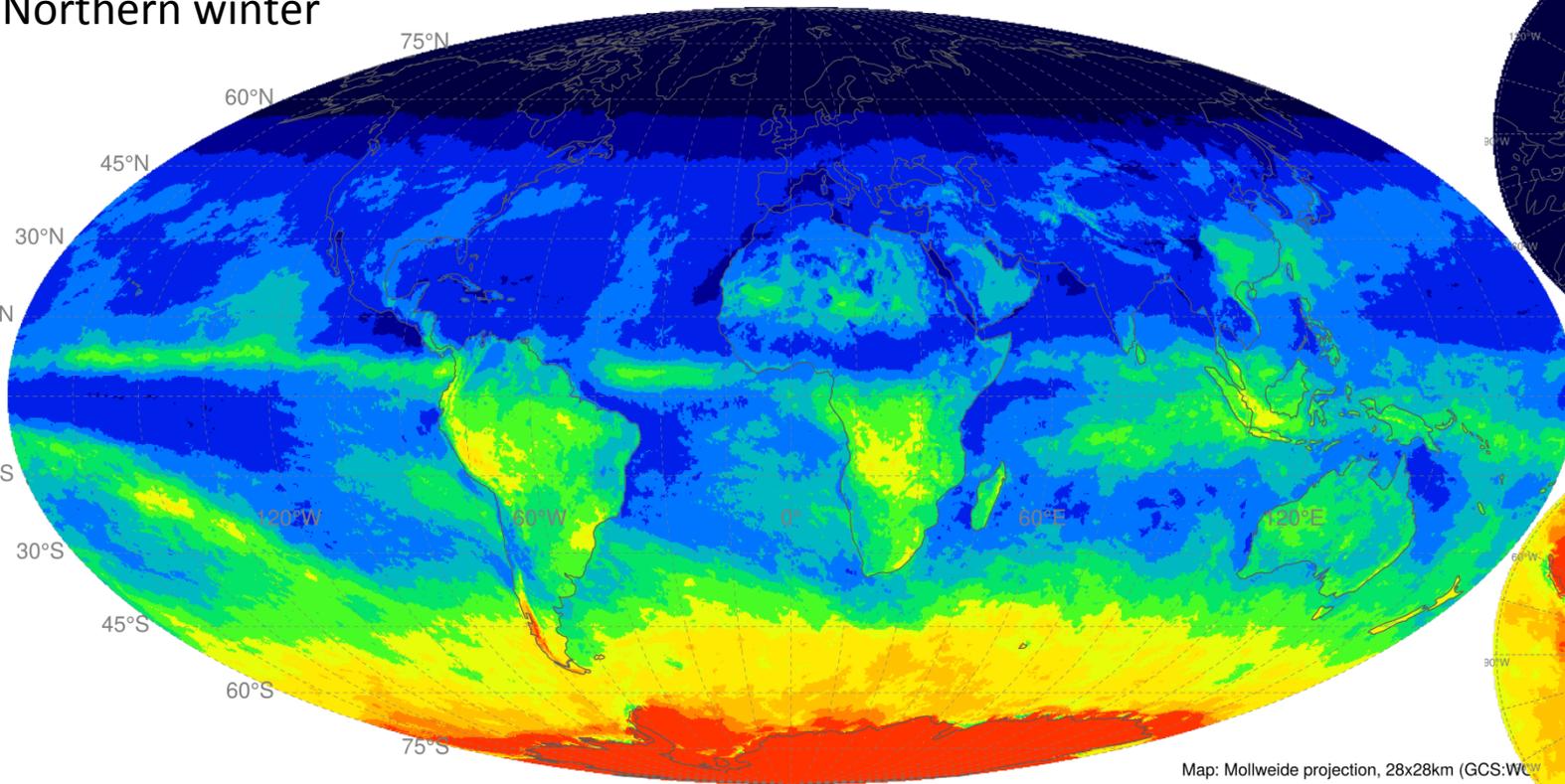
Map: Mollweide projection, 28x28km (GCS:WGS84)

3. Results/validation

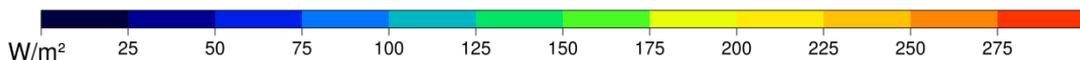
CLARA-A3 TOA SW radiation (201212)

Northern winter

Mean=110.05 W/m²



Map: Mollweide projection, 28x28km (GCS:WGS84)

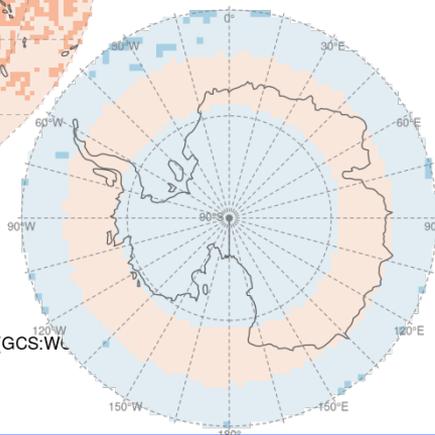
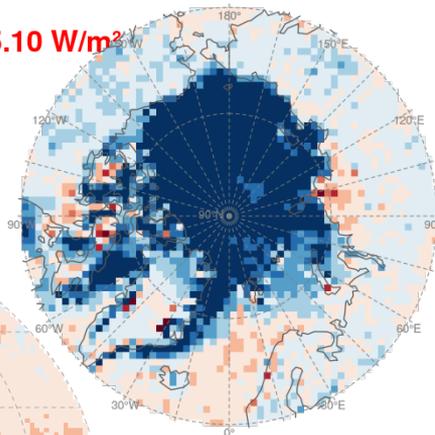
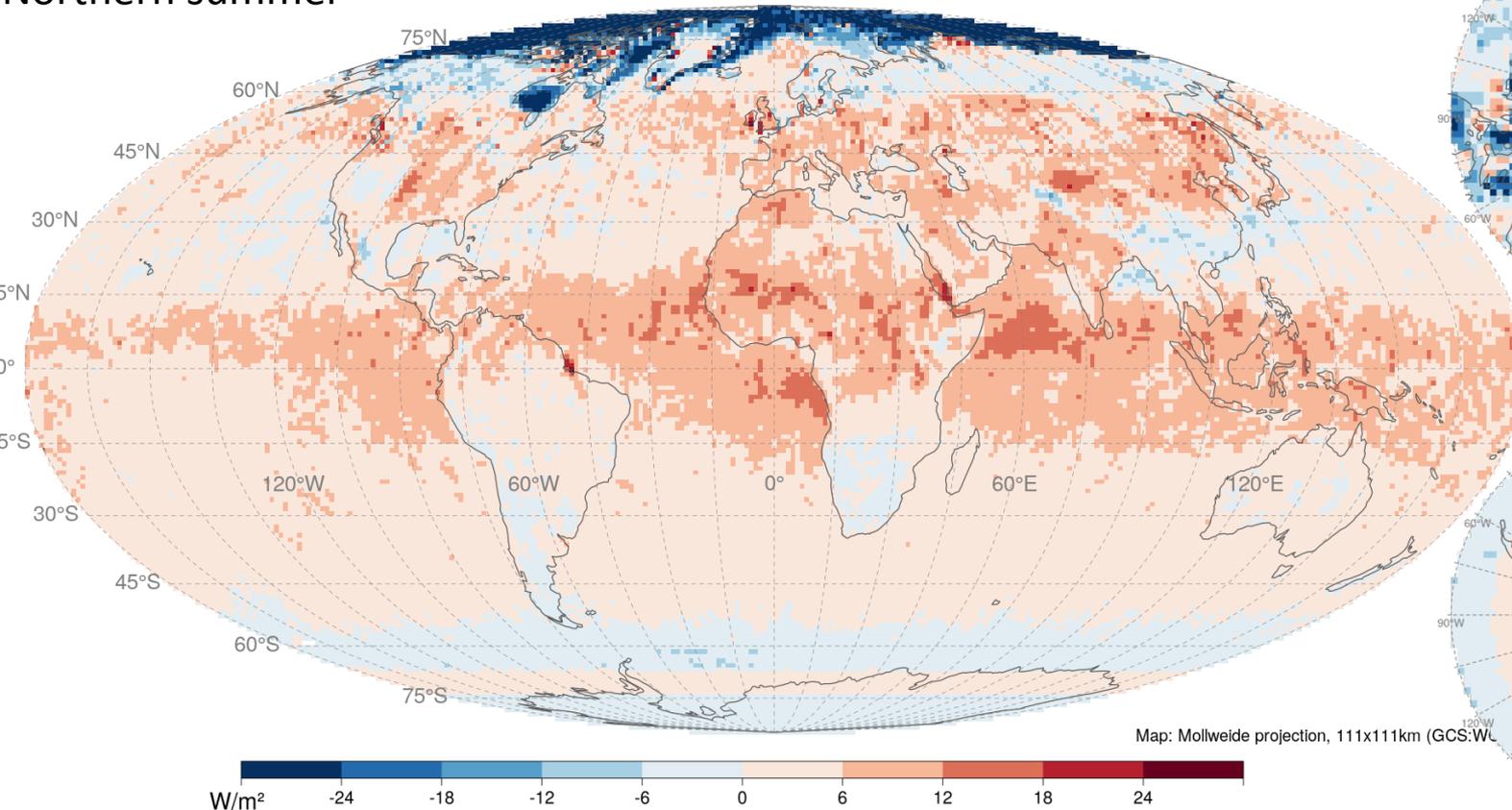


3. Results/validation

Bias of CLARA-A3 TOA SW radiation w.r.t. CERES-EBAF (201206)

ME=2.84 W/m²; MAE=5.10 W/m²

Northern summer

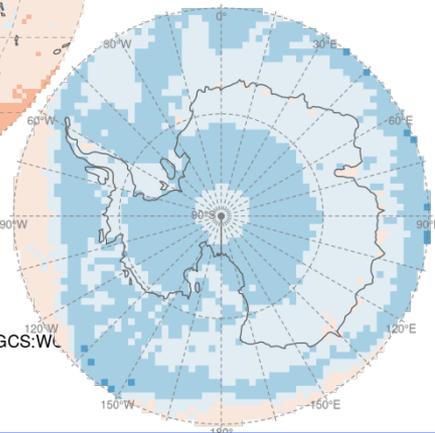
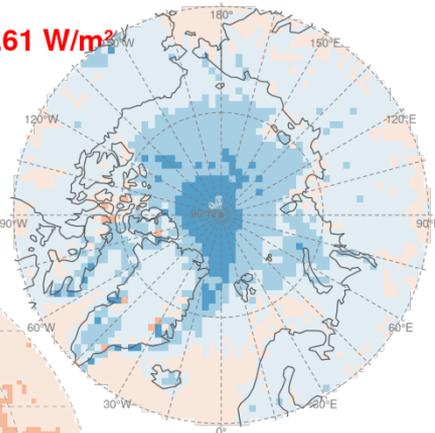
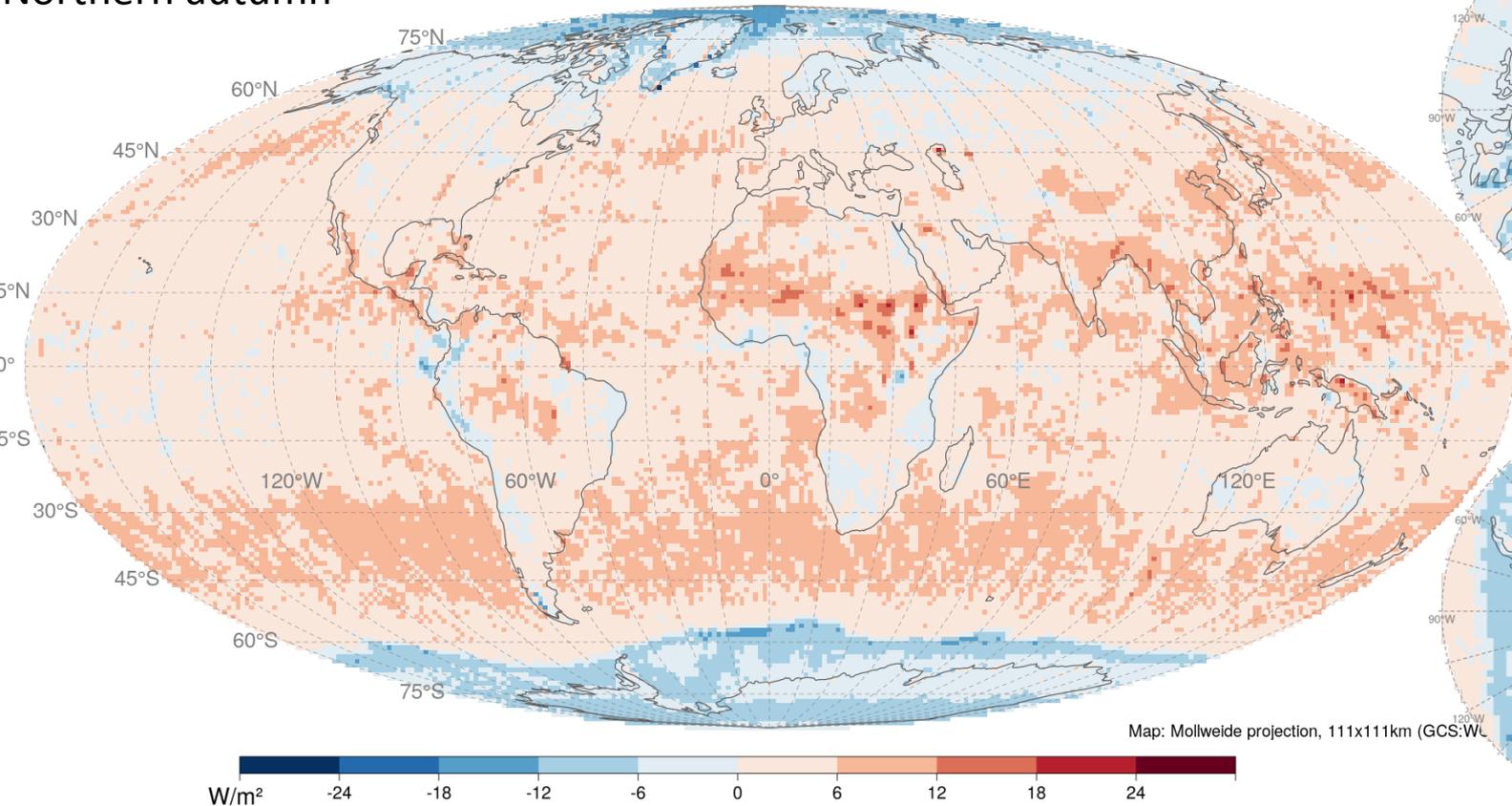


3. Results/validation

Bias of CLARA-A3 TOA SW radiation w.r.t. CERES-EBAF (201209)

ME=3.00 W/m²; MAE=4.61 W/m²

Northern autumn



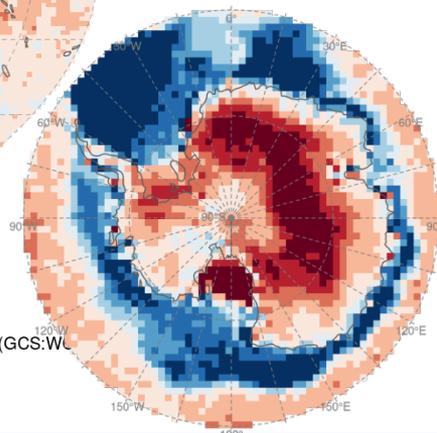
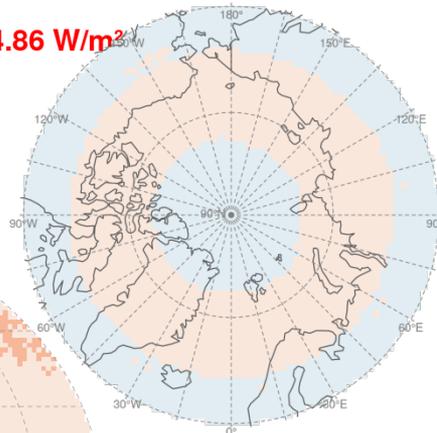
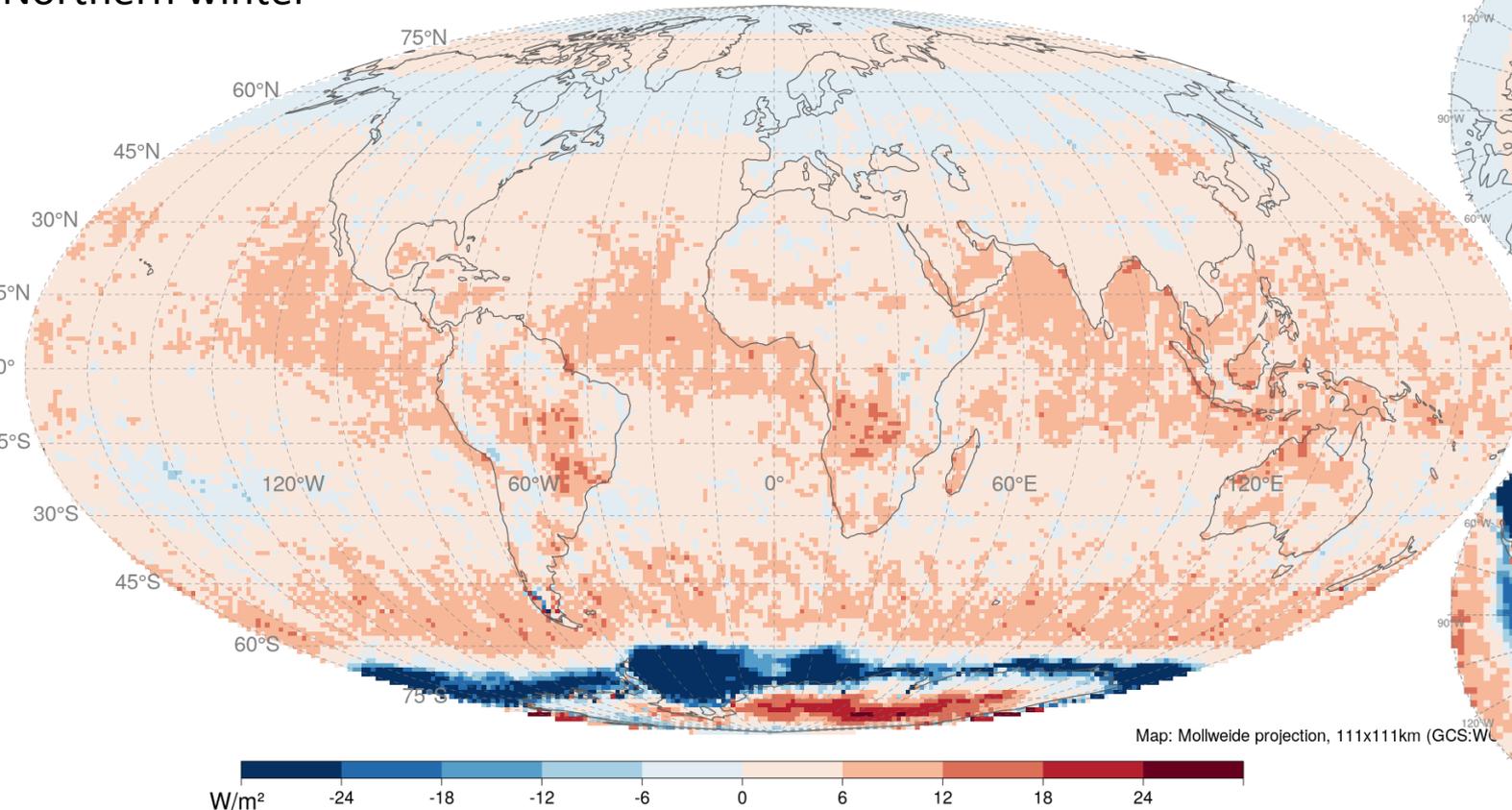
Map: Mollweide projection, 111x111km (GCS:WGS84)

3. Results/validation

Bias of CLARA-A3 TOA SW radiation w.r.t. CERES-EBAF (201212)

ME=2.72 W/m²; MAE=4.86 W/m²

Northern winter

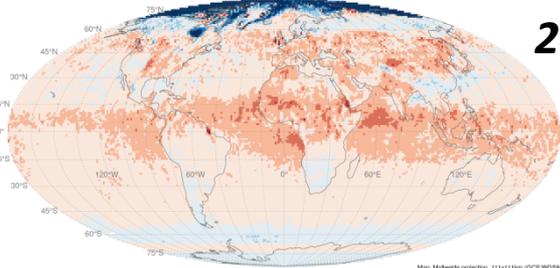


Map: Mollweide projection, 111x111km (GCS:WGS84)

ADM: CERES-TRMM/-TERRA

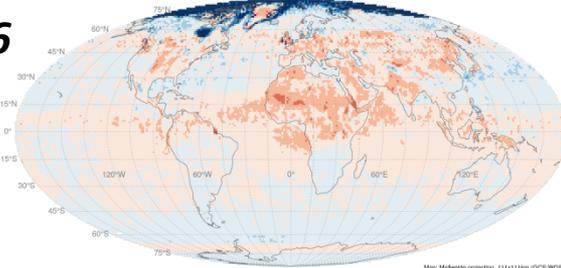
ADM: Suttles et al, 1988

+2.84 W/m²

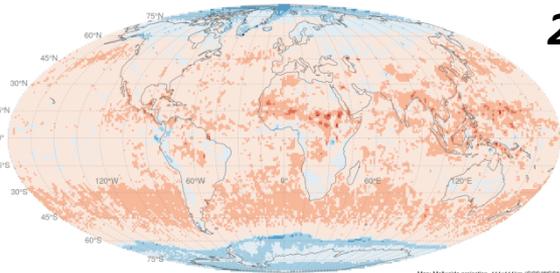


2012-06

+0.25 W/m²

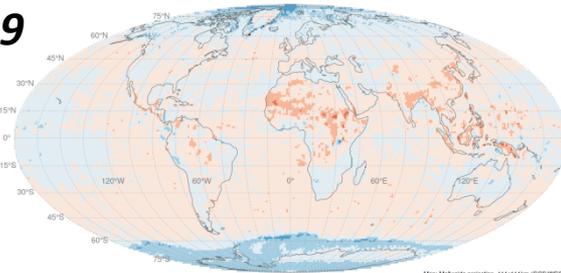


+3.00 W/m²

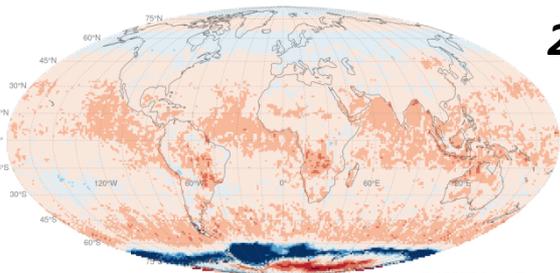


2012-09

+0.09 W/m²

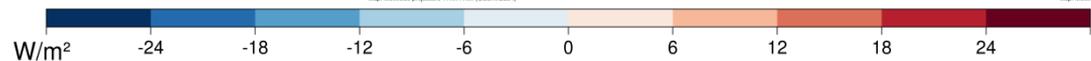
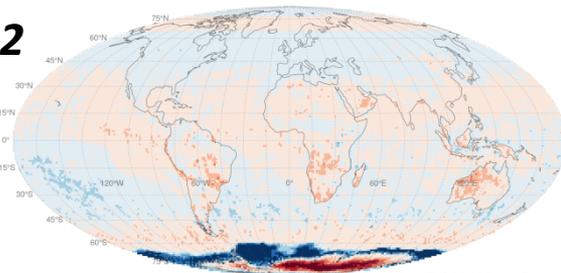


+2.72 W/m²

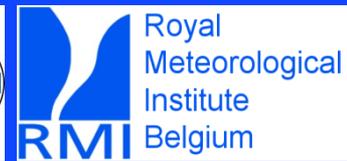
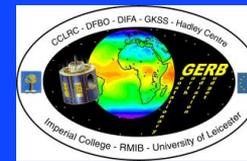


2012-12

-0.40 W/m²



- Ongoing work; CLARA-A3 official release foreseen around end of 2021 (preliminary date)
- Until now, mainly the shortwave radiation is considered; the part with longwave radiation is under development (challenges due to absence of water vapor channel in AVHRR)
- Lot to learn from CERES processing; (opportunity to make use of the newest ADM's?)



Thanks for your attention!

<tom.akkermans@meteo.be>

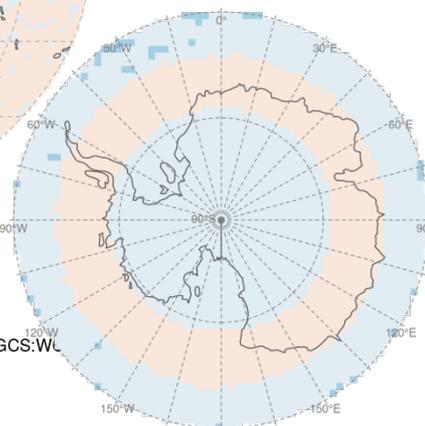
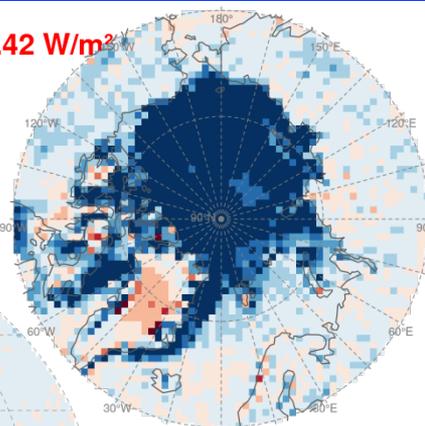
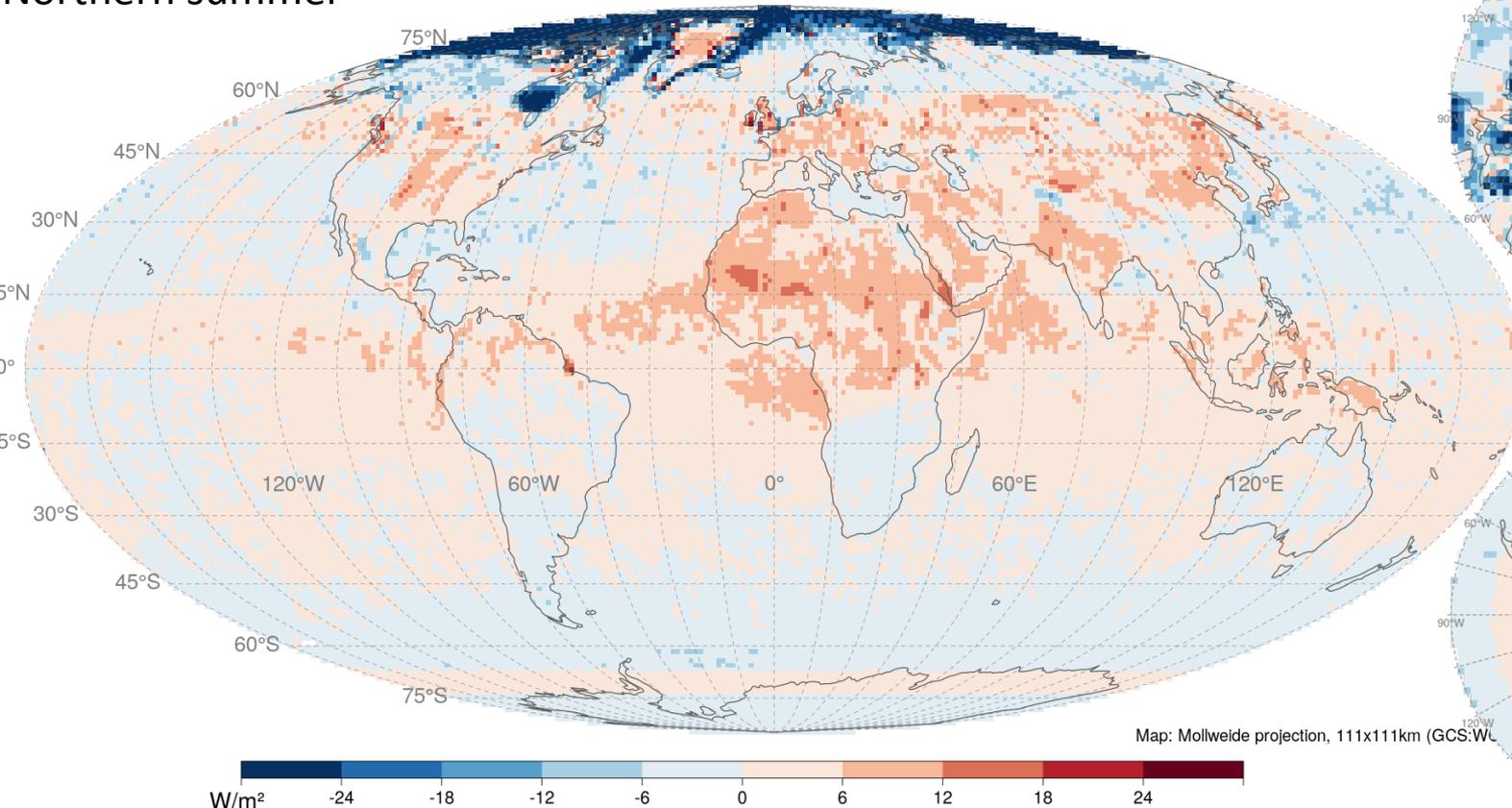
Extra slides

3. Results/validation

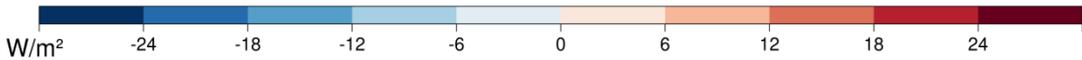
Bias of CLARA-A3 TOA SW radiation w.r.t. CERES-EBAF (201206)

Northern summer

ME=0.25 W/m²; MAE=3.42 W/m²



Map: Mollweide projection, 111x111km (GCS:WGS84)

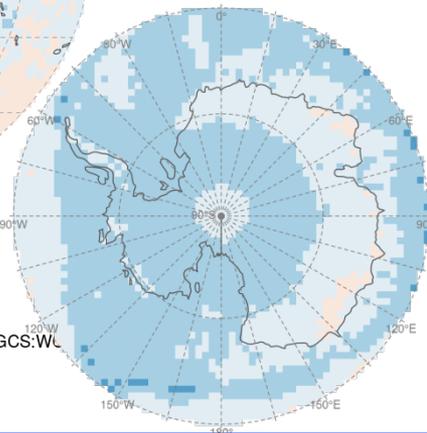
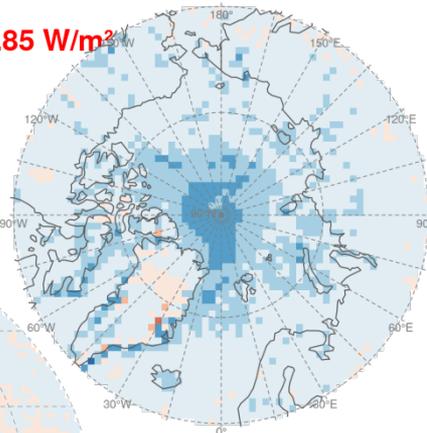
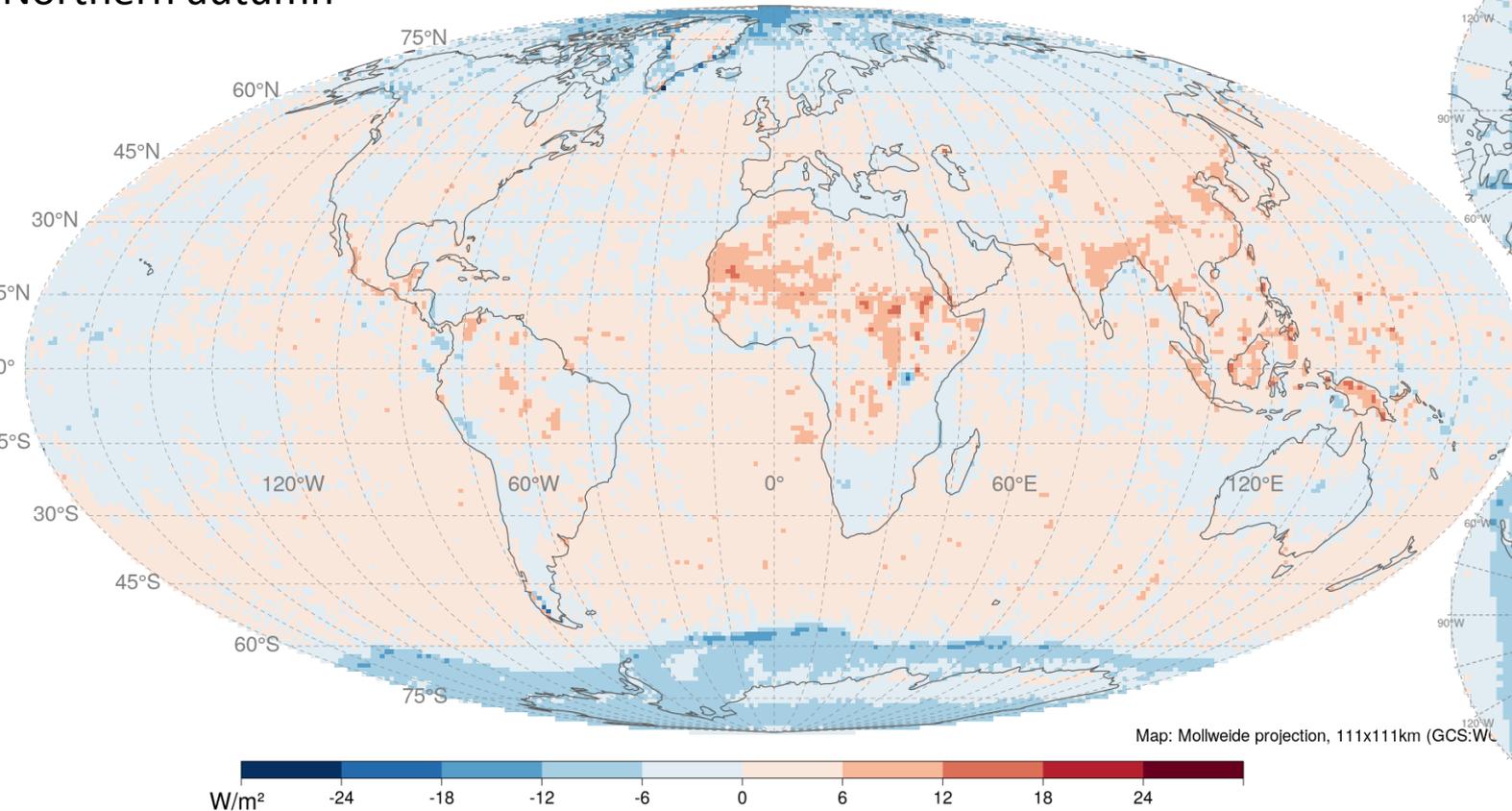


3. Results/validation

Bias of CLARA-A3 TOA SW radiation w.r.t. CERES-EBAF (201209)

ME=0.09 W/m²; MAE=2.85 W/m²

Northern autumn



Map: Mollweide projection, 111x111km (GCS:WGS84)

3. Results/validation

Bias of CLARA-A3 TOA SW radiation w.r.t. CERES-EBAF (201212)

ME=-0.40 W/m²; MAE=3.22 W/m²

Northern autumn

